Report for 2001PR2481B: Development of Novel Dual-Function Media Matrix for Protecting Water Resources from Noxious Organic Wastes - Phase II

There are no reported publications resulting from this project.

Report Follows:

SYNOPSIS

Project Number: Start: 03/01/2001
End: 02/28/2002

Title: Development of Novel Dual-Function Media Matrix for Protecting Water Resources from Noxious Organic Wastes – Phase II

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Focus Categories: WW, WQL, TRT, GW, ST

Congressional District: N/A

Descriptors:

Problem and Research Objectives:

The dual-functionality property of combinations of soil, sand, gravel and natural adsorbent is the major mechanism through which natural media and mother-nature protects environmental resources, including groundwater and arable land, from wastes injected in soils, landfills, caves and depleted wells/aquifers. By this mechanism wastes are immobilized within natural media by adsorption, absorption and encapsulation, and under favorable conditions the immobilized wastes biodegrade in a finite time. However, immobilization and biodegradation in natural media are not optimized to sustain continual injection of wastes without leading to pollution. This is mainly because the important media properties are bound to fail under certain environmental conditions: leakage of the media upon contact with heavy rainfall infiltration, flooding, and rising of the water table. Furthermore, in-situ biodegradation fails also to take place within a finite time if there are insufficient microbes and nutrients to sustain contaminant species reaction pathways. Another problem encountered in the treatment of large volumes of oily wastewater is that it is difficult to separate large amounts of oils & grease from wastewater. This investigation tackled the problem of developing novel cost-effective dual-function (filter) media for separation, immobilization and treatment of wastewaters containing high concentrations of oils & grease and odorous organic particulates.

The overall objective of this work was to develop and to determine the effectiveness of novel dual-function media matrix for the immobilization of odorous wastewater mixtures containing large quantities of oils and grease. The media and immobilized wastes were used to study and to optimize in-situ biodegradation. The wastewater used in this study contains high concentrations of oils and grease, varying between *500* to *10000 mg/L* range, and significant amounts of suspended solids. These wastewaters pose unique challenges since they contain high concentrations of oils, grease and odorous biodegradable solids. The objective of this work was to develop and to determine the effectiveness of novel dual-function media matrix for the immobilization of odorous waste mixtures containing oils and grease. The media and immobilized wastes were used to study and optimize in-situ biodegradation. The investigation used as a model

wastewater generated from the tuna industries at Mayaguez. Over a four-month period the average daily concentration of oils and grease was 2000 *mg/L* and 2800 *mg/L* of total suspended solids (TSS). The specific research objectives included: (i) conducting filtration and washing tests with the developed (dual-function) media matrix to immobilize oils & grease and suspended solids; (ii) in-situ biodegradation tests in secondary wastewater treatment; (iii) characterization and optimization of dual-functionality properties through packed bed experiments. The central focus was to develop effective and economical novel dual-function media to immobilize wastes and increase in-situ biodegradation rates through inoculation with oil eating microbes.

Methodology:

The investigation was divided into three major parts: separation of oils & grease and suspended solids from wastewater using dual-function filters; characterization of materials to find the right combination of matrix for immobilization and inoculation; and in-situ biodegradation in secondary treatment. The methodology and procedures are discussed below.

Separation step using dual-function filters: A high-efficiency depth filter was modified to function as a dual-function filter media by inserting immobilizing media matrix into the filter chamber.

The mixtures handled consist of combinations of wastewater, oily phase and odorous organic particulates. The first objective and primary treatment step was to separate the dispersed oily phase and particulates from the multicomponent wastewater mixture. Several materials (walnut, bagassee, corn, sand, and adsorbents) and their combinations were tried (in packed beds first) with the purpose to develop enhanced dual-function media matrix. Enhanced media consists of transport layers (membrane-like septum for high-pressure filtration) and a mass transfer zone (dual-function media matrix). The filtration characteristics and mass transfer rates of the enhanced media combination were then studied by generating a plugging curve for each media.

The study focused on understanding the complex fluid-solid interactions within the transport layers zone and in the media matrix (mass transfer) zone, and performance characteristics under different operating constraints. The penetration depth of oily phase and its effects on septum clogging characteristics, two-phase flow, and particulates and oily phase retention rates, immobilization of wastes and the effect of particle size in the depth (mass transfer) zone were established.

Generally, this part of the study included the following itemized tasks:

1. Sample preparation. Laboratory samples of multiphase mixture samples composed of organic solid, oils & grease, water, clay, polymer and sand were prepared from samples taken from the industrial facility. The candidate samples from industry were stored in sealed drums or containers. Analysis was done on every sample to amount of oils & grease before and after the filtration step The samples were added to the feed tank only when they were needed (*the samples need special handling and disposal*). At a later stage in the investigation the equipment was installed at the plant site.

2. Dual-function filter media preparation and loading. This involved
    - Particle size analysis of media material (a combination of clay, soil, sand, gravel, anthracite, a mixture of polymeric adsorbent and combinations of biosorbents: bagasse and walnut).
    - Immobilization studies dealt with selection of adsorbent and biosorbents based on oils/tar removal efficiency. The removal efficiency of each media was determined. Separate tests in batch mode were conducted to determine the most suitable combination adsorbent for a given oils and grease content in wastewater. These tests were quite cumbersome because raw wastewater samples tested contained 800 to 4000 *mg/L* oils & grease. Saturation tests were conducted on several media combinations in batch mode.
3. Separation experiments on test rig. These tests were carried out first on the high-efficiency dual function bag filter. The oils & grease and solids recovery efficiency was determined for various dual-function filter media.

The separator is a high efficiency (batch mode) filter shell into which the filter bags or cartridge filters are inserted. The filter bag type, see Fig. 1, is constructed of polyethylene materials with different micron size selection. The bags include additional transport layers attached to the bag. The media to trap the oils and odorous substances was inserted into the bag. The particulate solids and immobilized oils retained in the bags were used in further studies on washing, immobilization and biofiltration.

Immobilization, washing, biodegradation and biofiltration tests: The retained solids, sludge and dual-function media in the filter bags were conditioned for further tests. Additional materials were added to simulate injection site conditions but these studies are part of an on-going study. It is planned that the resulting material (solid matrix plus waste) will be added to the depth bed and washing tests will be conducted. The objective of these tests should be to determine the ability of the solid matrix to retain and immobilize oily wastes in light of extenuating conditions. The solid matrix will be optimized through further tests to maximize waste retention in a finite time.

The second objective of this investigation was to treat the remaining oils & grease from primary treatment by inoculating the wastewater with oil-eating microbes, the Biotech 2000 Formula IV. The microbes were established to be effective at biodegrading the oils & grease. The microbes were added to wastewater samples with approximately 25% of the original oils & grease and their effectiveness was established. In this part of study, analytical scheme based on UV absorption was developed to determine dynamically the degradation of oils & grease.

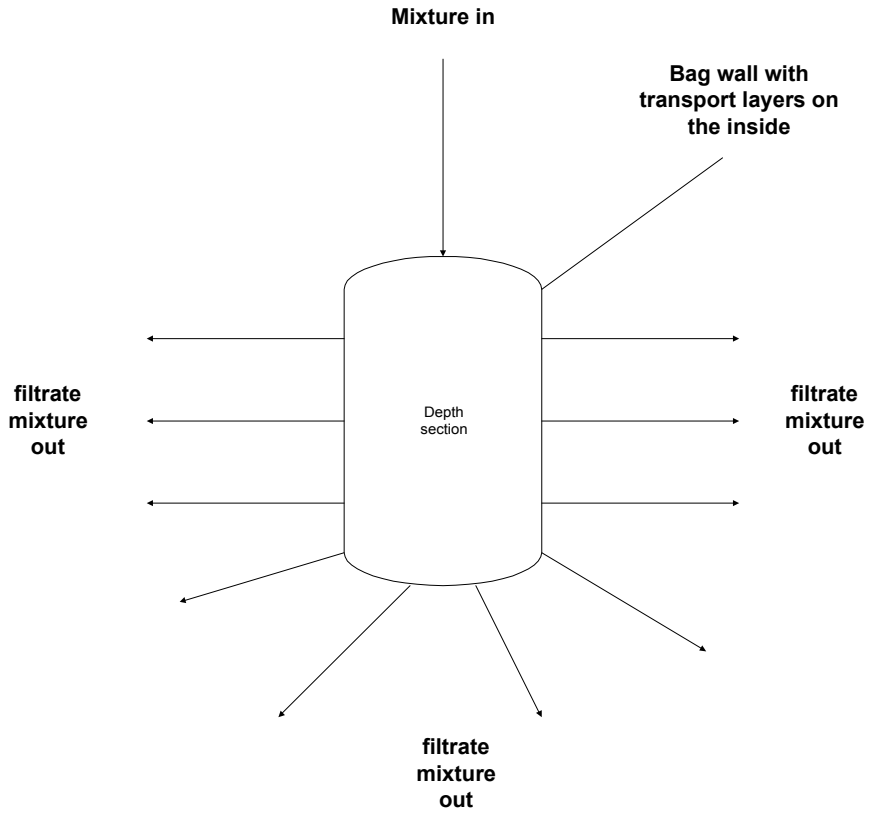

Figure 1 Filter bag

Further tests will be conducted in the future to determine the characteristics of injection site material (with the waste): its waste retention rates during washing and biodegradation rates (also during washing).

Principal Findings and Significance:

Over the previous 12 months the PIs have conducted studies related to Phase I & II of the investigation. The data generated has established that high efficiency depth filters are capable of separating oils/grease, odorous biodegradable solids and other solids from tuna wastewaters. The performance data obtained for various media indicate a significant improvement when 1 to 2 liters of matrix is added to bag filters (the results will appear in a paper to be published soon). And in order to evaluate the performance of the media, percentage removal of each filtration test was used as a basis for evaluating data. On average batch saturation tests and test rig experiments have established that the materials remove about 60 to 90% of oils & grease from raw wastewater, walnut producing the best results (the results will become available from the publication). The results for a combination of them will be published later. It has been established that any

conventional separation method usually fails in these circumstances (due to rapid fouling of the media). The results show that dual-functionality of the media once optimized is capable of immobilizing and biodegrading oily wastes/sludge. The key to fast and in-situ biodegradation is to embed a priori oil eating microbes and nutrients into the matrix. Generally this procedure should reduce the amount of sludge that is generated at the wastewater treatment site. The major candidates for dual-function media are walnut shells (bead-sized particles), bagasse and high-efficiency filter media (from Ronningen-Petter, a filter company). Additional tests are being conducted to determine the right media combination.

Publications

List all publications completed during the year as a result of work funded under Section 104 during the current budget period. Also list publications resulting from Section 104 work completed during previous budget periods if they were not included in a previous report.

1. Articles in refereed Scientific Journals

Author (last name, first name)	Bogere, Moses N.
Other authors (first name, last name)	Narinder K. Mehta and Daneira M. Colon
Year	2002 (submitted July 2002)
Title	Towards Effective Dual-Function Media for the Separation and Treatment of Wastewaters containing Oil & Grease
Name of Journal	Separation Science and Technology Journal
Volume (number)	
Page numbers	
Supporting Section 104 Project No.	(to be filled by the Institute office)

Author (last name, first name)	Bogere, Moses N.
Other authors (first name, last name)	Narinder K. Mehta and Daneira M. Colon
Year	2002 (under final preparation for submission)
Title	Plugging Curve Characteristics of Fibrous Media used as Dual-Function Media for removing Oil & Grease and Suspended Solids from Wastewater
Name of Journal	Chemical Eng. Commun.
Volume (number)	
Page numbers	
Supporting Section 104 Project No.	(to be filled by the Institute office)

2. Book Chapters

Author (last name, first name)	
Other authors (first name, last name)	
Year	

Title of Chapter	
Name of Editor(s)	
Title of Book	
Publisher	
City	
State	
Page numbers	
Supporting Section 104 Project No.	(to be filled by the Institute office)

3. Dissertations

Author (last name, first name)	Colon, Daneira
Year	2002 (to defend in August)
Title	Dev of Novel Dual-Function Media for Treatment and Separation of Oil & Grease from Tuna Wastewater
MS or Ph.D. dissertation?	MS
Departament	Civil Engineering
College	Engineering
University	University of Puerto Rico Mayaguez
City	Mayaguez
State	PR
Number of pages	
Supporting Section 104 Project No.	(to be filled by the Institute office)

4. Water Resources and Environmental Research Institute Reports

Author (last name, first name)	
Other authors (first name, last name)	
Year	
Title	
Name of WRERI	Puerto Rico Water Resources and Environmental Research Institute
University	University of Puerto Rico at Mayagüez
City	Mayagüez
State	Puerto Rico
Number of pages	
Supporting Section 104 Project No.	(to be filled by the Institute office)

4. Conference Proceedings

Author (last name, first name)	Colon, Daneira
Other authors (first name, last name)	Narinder K. Mehta and Moses N. Bogere
Year	2001 (February)
Title of Presentation	Effective novel dual-function media for separation and treatment of wastewaters

	containing oils & grease
Name of Editor(s)	Dr. Walter F. Silva-Araya
Title of Proceedings	Sixth Caribbean Islands Water Resources Congress
Publisher	PRWRERI
City	Mayaguez
State	PR
Page numbers	
Supporting Section 104 Project No.	(to be filled by the Institute office)

Bogere, M. N., Mehta, N. K. and Colon, D. M., Effect of Surfactants on Biodegradation Efficiency in the Secondary Treatment of Oily wastewaters, to be submitted to Colloids and Surfaces. A. PhysicoChemical & Engineering Aspects (2002).

5. Other Publications

Author (last name, first name)	
Other authors (first name, last name)	
Year	
Title	
Other information needed to locate publication	
Page numbers (if in publication)	
Number of pages (if monograph)	
Supporting Section 104 Project No.	(to be filled by the Institute office)

TRAINING ACCOMPLISMENTS

List all students participating in Section 104 projects.

Field of study	Academic Level				Total
	Undergraduate	MS	Ph.D.	Post Ph.D.	
Chemistry					
Engineering:					
Agricultural					
Civil	1	1			2
Chemical	1				1
Computer					
Electrical					
Industrial					
Mechanical					
Geology					
Hydrology					
Agronomy					
Biology					
Ecology					
Fisheries, Wildlife, and Forestry					
Computer Science					
Economics					
Geography					
Law					
Resources Planning					
Social Sciences					
Business Administration					
Other (specify)					
Totals	2	1			3*

* additional students (15) have used the experimental setup for undergraduate studies